



US009017867B2

(12) **United States Patent**
Liu et al.(10) **Patent No.:** US 9,017,867 B2
(45) **Date of Patent:** Apr. 28, 2015(54) **SELF ASSEMBLED MULTI-LAYER NANOCOMPOSITE OF GRAPHENE AND METAL OXIDE MATERIALS**(75) Inventors: **Jun Liu**, Richland, WA (US); **Ilhan A. Aksay**, Princeton, NJ (US); **Daiwon Choi**, Richland, WA (US); **Rong Kou**, Richland, WA (US); **Zimin Nie**, Richland, WA (US); **Donghai Wang**, Richland, WA (US); **Zhenguo Yang**, Richland, WA (US)(73) Assignees: **Battelle Memorial Institute**, Richland, WA (US); **The Trustees of Princeton University**, Princeton, NJ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 320 days.

(21) Appl. No.: **12/462,857**(22) Filed: **Aug. 10, 2009**(65) **Prior Publication Data**

US 2011/0033746 A1 Feb. 10, 2011

(51) **Int. Cl.**

H01M 4/62 (2006.01)
H01M 4/36 (2006.01)
H01M 4/485 (2010.01)
H01M 4/505 (2010.01)
H01M 4/525 (2010.01)
H01M 4/66 (2006.01)
H01M 10/0525 (2010.01)

(52) **U.S. Cl.**

CPC **H01M 4/624** (2013.01); **Y10T 156/10** (2013.01); **Y10T 428/30** (2013.01); **H01M 4/366** (2013.01); **H01M 4/485** (2013.01); **H01M 4/505** (2013.01); **H01M 4/525** (2013.01); **H01M 4/663** (2013.01); **H01M 10/0525** (2013.01); **Y02E 60/122** (2013.01); **Y02T 10/7011** (2013.01)

(58) **Field of Classification Search**

CPC H01M 4/624; H01M 4/525; H01M 4/485; H01M 4/366; H01M 4/663; H01M 4/505; H01M 10/0525; Y10T 428/30; Y10T 156/10; Y02T 10/7011; Y02E 60/22
USPC 429/209, 122; 423/448; 29/592
See application file for complete search history.

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(57) **ABSTRACT**

Nanocomposite materials having at least two layers, each layer consisting of one metal oxide bonded to at least one graphene layer were developed. The nanocomposite materials will typically have many alternating layers of metal oxides and graphene layers, bonded in a sandwich type construction and will be incorporated into an electrochemical or energy storage device.

24 Claims, 19 Drawing Sheets